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Exploring high-performance green innovation in China's logistics companies: a TOE framework based on fsQCA

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In recent years, the Chinese logistics industry has experienced rapid development. However, this expansion is accompanied by significant challenges, including high energy consumption and greenhouse gas emissions. Despite these issues, the key factors improving logistics firms' green innovation remain insufficiently explored. This study fills this gap by utilizing the Technology-Organization-Environment (TOE) framework as a foundation, introducing a comprehensive analytical model to investigate the dynamics of green innovation in logistics companies. Moreover, after employing fuzzy-set Qualitative Comparative Analysis (fsQCA) with data from 83 logistics firms in China, the research examines the complex interplay between technological, organizational, and environmental factors and their strategic influence on green innovation performance. The study yields three pivotal findings: (1) High-level green innovation performance is not predicated on a single factor. (2) Logistics firms can attain superior green innovation performance through two driving paths: Core competencies and market pressure driven as well as technological innovation and government subsidies driven. (3) The analysis of low-level green innovation performance reveals that four distinct paths can culminate in this outcome, with the lack of digitalization, organizational slack, and market pressure being instrumental in this result. These insights highlight the principles of "multiple concurrency" and "different paths leading to the same goal," significantly enhancing the current knowledge base on green innovation performance and deepening our understanding of the multifaceted drivers of high-performance green innovation in logistics companies. Moreover, the discoveries offer practical implications for firms and the government to improve green innovation performance within the logistics industry.

KEYWORDS

green innovation performance, sustainable development, logistics enterprises, TOE framework, fsQCA

1 Introduction

Over the past decade, with the maturation and expansion of e-commerce, China's logistics market has grown rapidly and has been the world's largest logistics market since 2014. According to data from the National Bureau of Statistics of China, the total volume of social logistics in China reached $41.09 trillion in 2023, representing a year-on-year increase of 7.5%. Furthermore, the added value generated by the logistics sector accounted for 14.5% of China's GDP, highlighting its significant role in driving consumption and facilitating trade within the national economy. However, this sector also faces substantial challenges, including high energy consumption and greenhouse gas emissions. For instance, in 2022, total logistics costs in China reached 18.2 trillion yuan (14.4% of GDP), significantly higher than the stable 8%–9% seen in developed countries. Moreover, the logistics industry is one of the most energy-intensive sectors, with its greenhouse gas emissions accounting for approximately 9% of China's total CO2 emissions. Therefore, when facing these challenges, logistics enterprises must adopt strategic approaches to balance profit generation with ecological protection, thereby improving their green innovation performance and achieving Chinese logistics sectors' long-term sustainability and "Dual Carbon" goals (Xu and Li, 2024).

To achieve superior green innovation performance in logistics, scholars have conducted extensive research to explore various influencing factors of green innovation in logistics firms (Green et al., 2012; Chu et al., 2017; Sureeyatanapas et al., 2018; Jazairy and von Haartman, 2019; Inkinen and Hämäläinen, 2020; Cichosz et al., 2020; Xu and Li, 2024). For example, from the policy perspective, Sharma et al. (2022) found that areas with strict environmental regulations tend to exhibit lower pollution levels. By adopting the executives' perspective, Chen et al. (2022) demonstrated that executives with overseas experience positively influence firms' green innovation. From a consumer perspective, Sureeyatanapas et al. (2018) found that customer pressure seems essential to improve the degree of green logistics implementation. While previous studies have offered valuable implications for logistics' green innovation, the current literature primarily focused on the single-dimensional approach, lacking a comprehensive exploration from both the internal and external dimensions.

Actually, the factors influencing the green innovation of logistics companies can be divided into external and internal categories. External factors include government policies (including environmental regulations, energy subsidies, etc.), market competitive pressures, and so on (Inkinen and Hämäläinen, 2020; Sharma et al., 2022). Internally, factors such as organizational and technological innovation and top management team heterogeneity (TMT) have been identified as key influences on green innovation (Xu and Li, 2024). Previous research often neglects the synergistic interactions between internal and external factors (Li et al., 2022), failing to fully explore the complicated relationships affecting logistics enterprises' green innovation. This gap highlights the current research limitations and the necessity to employ a comprehensive approach to explore the pathways for the high-level green innovation of logistics firms. Therefore, we use the Technology-Organization-Environment (TOE) framework as a theoretical lens to explore the synergies between internal and external factors in logistics firms. This approach offers systematic and in-depth insights regarding the driving forces behind green innovation, thereby advancing the academic comprehension of superior green innovation performance in logistics firms and bridging the existing research gaps.

Furthermore, existing literature predominantly uses case study analyses or quantitative methods (Sun et al., 2020; Sandra Marcelline et al., 2022; Wan et al., 2022). These methods offer solid statistical evidence for uncovering green innovation performance in logistics enterprises. However, they still have certain limitations. Quantitative approaches, such as Principal Component Analysis (PCA), regression analysis, and Propensity Score Matching (PSM), are adept at identifying broad patterns from large datasets but often fail to capture the nuanced complexities and causal relationships. In contrast, while providing detailed insights into individual cases, conventional qualitative analyses lack the ability for broader generalization. Given the complexity of achieving high green innovation performance in logistics, a more refined methodological approach is necessary. Fuzzy-set Qualitative Comparative Analysis (fsQCA) addresses the limitations of both qualitative and quantitative methods, making it suitable for analyzing both large samples (over 50 cases) and smaller samples (less than 10 to 50 cases).

In conclusion, while significant progress has been made in green innovation research within the logistics sector, existing studies often neglect the interactions between external and internal factors. Previous studies have primarily focused on the impact of isolated variables and ignored asymmetric causality, which is essential for understanding the complex dynamics of green innovation in logistics enterprises. Using data from credible sources, such as the WIND and annual reports from 83 listed logistics companies, this study employed fuzzy-set qualitative comparative analysis (fsQCA) to identify the key drivers and critical combinations of conditions that lead to high-level green innovation performance in logistics enterprises. This study examines the integration of green innovation into logistics management, aiming to identify the factors influencing organizational green innovation and expand the research on green innovation performance, enriching TOE theory. It provides insights for managers to understand the complex, synergistic factors that affect green innovation and balance economic growth with environmental protection, offering government policy recommendations and practical guidance for logistics enterprises. By addressing previous research's methodological and theoretical limitations, this study provides a comprehensive view of the interactions between factors in logistics firms, bridging the gap between theory and practice.

2 Literature review and theoretical framework

2.1 Literature review

With the increasing resource, environmental, and ecological concerns, Fussler and James (1996) first introduced the concept of green innovation. This concept emphasizes the balance between economic development and environmental protection, advocating for sustainable practices that promote economic growth while concurrently improving resource efficiency and environmental quality. For enterprises, green innovation serves as a crucial strategy to attain market legitimacy and competitive advantage in intense market competition (Wang et al., 2019). By integrating green principles throughout the innovation process and employing advanced technologies to enhance products and services, companies can effectively conserve resources while addressing environmental challenges (Lv et al., 2021; Yingfei et al., 2022; Ding et al., 2023). In the logistics sector, green innovation focuses on reducing energy consumption, emissions, and costs. Companies enhance operational efficiency by integrating green principles into transportation, warehousing, and packaging and contribute to the industry's sustainable transformation.

As awareness of the environmental impact of the logistics industry has increased, research related to the green innovation performance in logistics companies has also begun to emerge. Overall, however, current research on this area remains limited. Scholars have applied a limited range of theoretical frameworks, including the sustainable development theory, stakeholder theory, and institutional theory (Lintukangas et al., 2016; Wang, 2019; Chu et al., 2019). For instance, Chu et al. (2019) adopted the stakeholder and institutional theories and concluded that Third-party logistics (3PL) firms can foster green innovation by granting employees more autonomy and flexibly designing operational procedures to meet customers' environmental requirements. Similarly, Wang (2019) employed the perspective of sustainable development theory and found that green product design, green logistics distribution, and green logistics packaging positively affect logistics performance. While the valuable insights provided by these studies, certain limitations persist. Theoretical frameworks such as sustainable development theory, stakeholder theory, and institutional theory focus on internal drivers while potentially overlooking external factors, including government policies and market conditions, and the complex interplay between internal and external influences. This narrower focus may limit the robustness and comprehensiveness of the research outcomes, suggesting a need for future studies that integrate a broader range of variables.

To address theoretical challenges, this study applies the Technology-Organization-Environment (TOE) framework (Tornatzky and Fleischer, 1990), analyzing factors from internal (technology, organization) and external (environment) angles. This integrated approach bridges theoretical gaps, deepens understanding of factor interactions, and uncovers mechanisms for high-level green innovation in logistics enterprises. By exploring these dimensions, the TOE framework identifies drivers and barriers to green transformation, offering insights into optimizing management practices and technology investments while adapting to environmental regulations and societal expectations, thus fostering sustainable innovation in logistics.

2.2 Theoretical framework

2.2.1 The TOE framework theory

The Technology-Organization-Environment (TOE) framework, initially proposed by Tornatzky and Fleischer (1990), is a comprehensive analytical tool for examining the various factors influencing a firm's decision to adopt and implement new technologies. In essence, the TOE framework categorizes these influential factors into three distinct groups: technological, organizational, and environmental. Specifically, technical aspects refer primarily to factors intrinsic to the technology, such as the maturity, complexity, prospective benefits, and compatibility with existing systems. These factors determine the attractiveness and adoption challenges that technology presents to an organization (Ganda, 2019). Organizational conditions play a pivotal role in shaping the extent of a company's green innovation efforts and have become a focal point within empirical research. These conditions encompass a spectrum of factors, such as the organizational climate, size, structure, the composition of the senior management team, and communication mechanisms (Abed, 2020). These factors influence the organization's capacity and willingness to adopt new technologies. The environmental conditions refer to the distinctive features of the organization's setting, encompassing its dynamics with the industry, competitive landscape, and governmental entities (Yoon et al., 2020). These factors shape the external conditions and pressures within which the organization operates, impacting its decisions. The TOE framework has been widely applied in various fields, including governance and digital transformation, and continues to evolve and expand its influence. It is an integrative analytical framework where dimensions are intricately linked and reciprocally influence one another, collectively impacting the conduct and efficacy of green innovation within companies.

In the increasingly complex environment logistics companies face, their green innovation performance is influenced by multiple factors. Traditional symmetrical causal relationships are limited in their capacity to explain green innovation performance and restrict the selection of pathways available to firms. Therefore, research on the green innovation performance of listed logistics companies should adopt a more comprehensive perspective that analyses multiple antecedent conditions. Consequently, this study employs the TOE framework to study the green innovation performance of logistics firms due to the following specific considerations. First, the TOE framework is a comprehensive analytical tool that examines the various factors from three dimensions (technological, organizational, and environmental). This categorization aligns well with the considerations that logistics companies must address when pursuing green innovation. Moreover, given the environment's dynamic and multifaceted nature, logistics companies' green innovation performance is influenced by various factors. In pursuing green innovation, logistics firms must consider not only the characteristics of the technology itself but also organizational aspects—such as size, structure, and culture—as well as environmental factors, including regulatory policies and market competition. The TOE framework effectively encapsulates these dimensions, providing a holistic configurational perspective to analyze multiple antecedent conditions. Finally, the TOE framework allows researchers to tailor the specific variables within each category to the particular research context, thus offering greater flexibility and operability. As the factors influencing green innovation performance may vary across different market and policy environments, the TOE framework can effectively accommodate these variations, making it an ideal choice for this study.

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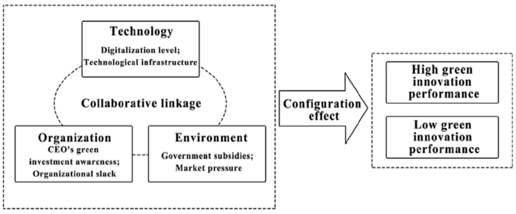

FIGURE 1
The configurational framework of green innovation of logistics firms.

2.2.2 Construction of the framework

In this study, we explore the capacity of logistics companies to undertake green innovation, which is influenced by a complex interplay of internal technological factors, organizational dynamics, and external environmental conditions. These determinants do not operate in isolation; they interact and converge to shape a company's strategic direction. Recognizing the distinctive traits and advancements in corporate green innovation, we establish a comprehensive analytical framework (Miao and Zhao, 2023). This framework consists of three primary dimensions—technological, organizational, and environmental factors—each comprising specific secondary conditions, including the digitalization level, technological infrastructure, CEO's green investment awareness, organizational slack, government subsidies, and market pressure. Through an empirical examination of various pathways to green innovation from a configurational perspective, this study elucidates the synergistic and alternative interactions among these multitiered factors. Figure 1 illustrates the theoretical model framework developed for this analysis.

First, at the technological level, we select the digitalization level and technology infrastructure as our representative variables. The digitalization level represents the extent to which logistics companies integrate digital technologies into their operations, thereby enhancing their ability to innovate green solutions and respond effectively to environmental challenges, which is essential for improving environmental performance and achieving sustainable competitive advantages (Liu et al., 2023). Technology infrastructure encompasses the physical and software components that form the backbone of a company's technological capabilities, facilitating the development, implementation, and maintenance of green technologies and processes, which is a significant factor in determining its success in the evolving eco-conscious business landscape (Tang et al., 2021).

Second, we select CEOs' green investment awareness and organizational slack as the representative variables at the organizational level. The CEO's green investment awareness reflects the executive leadership's commitment to environmental sustainability, showing that logistics firms pay attention to the influence of their enterprises' actions on the environment, which is pivotal for driving green innovation initiatives and fostering a culture of ecological responsibility within the company (Tan and Zhu, 2022). Organizational slack represents the excess resources available to an organization that can be redirected toward green innovation efforts, thus providing the flexibility and resilience necessary to adapt to environmental challenges and pursue sustainable growth strategies (Diwei Lv et al., 2020).

Third, we select government subsidies and market pressure as the representative variables at the environmental level. Due to the increasingly strict environmental restrictions, firms must invest more in green innovation. Government subsidies represent the financial support from the state that can alleviate the capital constraints faced by logistics companies in their pursuit of green innovation, thereby enhancing their capacity to adopt environmentally friendly technologies and practices (Wu and Li, 2021). Market pressure is selected because it encapsulates the competitive and consumer demands that drive logistics firms to prioritize and invest in green innovation, ensuring that their operations align with ecological standards and sustainability expectations in the face of stringent ecological regulations (Zhang et al., 2020).

3 Research methodology and data processing

3.1 Research method

Qualitative Comparative Analysis (QCA), initially introduced by Charles Ragin in 1987, is a methodology that focuses on cases and is particularly suitable for datasets that are not large enough for linear regression but too extensive for singular case analysis (Ragin and Strand, 2008). This approach contests key presuppositions of traditional statistical techniques, expanding the scope of causal inquiry by reevaluating certain underlying assumptions. The utility of QCA has been increasingly recognized in management studies, where the research problem is often "result-driven" and "configuration" (Gligor et al., 2022). For instance, Yuan et al. (2023) utilized fsQCA to examine the combinations of six factors—digital technology, R&D capability, dynamic capability, enterprise scale, resource constraints, and competitive pressures—on the green transformation of heavily polluting firms. Distinct from conventional statistical approaches that seek a single best-fitting causal model, QCA endeavors to reveal multiple causal pathways, highlighting the multifaceted nature of causality and discerning various causal patterns among a range of conditions. Among the QCA variants, Ragin's QCA stands out for its ability to dissect intricate causal dynamics and contextual influences within complex interventions (Schneider, 2018). QCA comprises three primary forms: crisp-set QCA (csQCA), multi-value QCA (mvQCA), and fsQCA. While csQCA and mvQCA operate with binary and simple multi-value variables, they may lead to inconsistent configurations. fsQCA offers a more nuanced and stringent assessment of set theory consistency, as it employs precise multi-value variables and a robust QCA framework to maintain coherence and preclude contradictory outcomes (Liu and Pan, 2024). Consequently, this study opts for fsQCA to explore the developmental pathways of logistics companies.

3.2 Case selection and data collection

First, the research subject of this paper is listed logistics companies. Based on the definition of logistics companies provided earlier, the data of 90 Chinese logistics companies listed on the A-shares and Hong Kong stock markets are selected as the initial research sample. Considering the principles of availability, completeness, and comparability of the data, the dataset excludes the following cases: (1) cases with severe missing data; (2) cases marked as ST (Special Treatment) or *ST (Special Treatment with Risk Warning). In the Chinese stock market, ST signifies companies with consecutive annual losses, while ST highlights those at heightened delisting risk if financial losses persist; (3) companies listed for less than one year; (4) companies undergoing relisting in other markets. Ultimately, 83 cases remained (54 from A-shares and 29 from Hong Kong stocks). This study selected six antecedent variables, and the number of cases chosen meets the requirements of the fsQCA method, which states that the number of cases should not be less than 2n-1 when there are n conditional variables (i.e., at least 32 cases). This paper selects the green innovation data of listed logistics companies for 2023. Due to the time-lag effect in the outcomes of corporate green innovation, the antecedent conditions were lagged by one period, and the data was sourced from 2022.

Second, this study's raw data for the digitalization level, technology infrastructure, CEO's green investment awareness, organizational slack, government subsidies, and market pressure come from the China Stock Market Accounting Research (CSMAR) database, Wind database, or annual reports of listed logistics firms. Data related to the proportion of R&D expenses and R&D personnel, as well as ESG evaluation and green innovation patents, are sourced from the websites of the National Intellectual Property Administration, CSMAR, and Wind.

3.3 Variable measurement

In this study, green innovation performance is set as the result variable. The digitalization level, technology infrastructure, CEO's green investment awareness, organizational slack, and government subsidies are set to be condition variables.

3.3.1 Result variable

The result variable is green innovation performance. Scholars have posited that a single metric is insufficient to assess the company's green innovation performance fully and effectively (Yi et al., 2021; Zhao et al., 2022; Yang et al., 2022). Consequently, this study draws upon the comprehensive assessments by Wang et al. (2017) and Gao et al. (2021), evaluating corporate green innovation from both input and output perspectives. Specifically, the input of a company's investment in green innovation is reflected by the proportion of R&D expenditures in total revenue and the ratio of R&D personnel. The output of green innovation is gauged by the ESG (Environmental, Social, Governance) evaluation, an enterprise assessment criterion that emphasizes a company's performance in terms of environmental, societal, and governance aspects, as well as the number of green patent applications (Wu and Li, 2021). After obtaining indicators for both the input and output, the entropy weight method is employed to objectively assign weights to each indicator. These are then measured separately for innovation input and output, culminating in an aggregated green innovation index representing corporate green innovation.

3.3.2 Antecedent variables

3.3.2.1 The first is technological conditions

The technological conditions comprise two sub-conditions: the digitalization level and technology infrastructure. Digitalization level: This study follows the methods of Fang and Li (2024) to assess the digitalization level within firms via text analysis. Specifically, the methodology involves initially utilizing keywords across five dimensions—"AI," "big data," "cloud computing," "blockchain," and "digital technology"—to construct a feature word spectrum. Subsequently, the negated terms preceding keywords are excluded. The 2022 annual report is selected as the source for textual analysis, and NVivo 14 is used to search and construct an index system for the corporate digitalization level based on term frequency. Finally, to address the "right-skewed" data, this study adds one to the data and takes the natural logarithm to portray an overall indicator of the corporate digitalization level.

Technology infrastructure: In light of data availability and the limitations of the aforementioned metrics for digitalization, this investigation, guided by the research of Li et al. (2022), evaluates the extent of investment in digital technology infrastructure. The specific calculation method involves the proportion of investments in hardware and software equipment with digital capabilities relative to the total corporate asset value. Hardware investment is identified through items such as "electronic devices," "office electronic equipment," "computer equipment," "automation," "electronic instruments," "communication," and so on within fixed assets. Software investment is categorized under intangible assets, including "software," "systems," "computers," "e-commerce," "platforms," "databases," and "WeChat public accounts," etc. To guarantee that the data are both comprehensive and precise, the following treatments have been applied: (1) To address the missing data, either the year-end value from the prior year or the year-start value from the subsequent year is utilized to fill the blanks; (2) For digital-related investments, such as electronic equipment listed under office equipment, or other categories in different years, and software listed under patents, or other categories, we contrast the year-end figure from the preceding year against the year-start figure from the ensuing year to complete the missing information; (3) Data that cannot be separated from other project investments in digital investments are excluded.

3.3.2.2 The second is organizational conditions

Organizational conditions encompass the CEO's awareness of green investments and the organization's slack. CEO's awareness of green investments. In small-scale businesses, it is difficult to directly assess the CEO's understanding of environmentally friendly investment opportunities. This study refers to the text analysis method (Chiţimiea et al., 2021) but makes necessary modifications. Specifically, considering the focus on the CEO's understanding of the necessity and feasibility of green investments, the "Discussion and Analysis on the Future Development of the Company" section in the 2022 annual report's "Operating Conditions/Management Discussion and Analysis" is selected as the unit for text analysis. Using NVivo 14, we conducted text searches for keywords such as "green environmental protection" and "green ecological protection." The

TABLE 1 Variable measurements and data sources.

Types		Names	Symbols	Measurements	Units	Data sources
Outcome		Green innovation performance	GIP	1. Represent input by the proportion of R&D expenses in business revenue and the proportion of R&D personnel; 2. Represent output by ESG evaluation and the volume of green patent applications; 3. Use the entropy weight method to measure input and output, ultimately obtaining the corporate green innovation performance.	%	CSMAR, WIND and CNRDS
Antecedent conditions	Technological conditions	Digitalization level	DL	The word frequency of Digitalization is transformed by adding one and taking the natural logarithm	Number of words	Annual report
		Technology infrastructure	TI	The proportion of investment in hardware and software equipment with digital capabilities to the total corporate asset value	%	CSMAR and annual report
	Organizational conditions	CEO's green investment awareness	CGIA	The word frequency related to the CEO's green investment awareness is transformed by adding one and taking the natural logarithm	Number of words	Annual report
		Organizational slack	OS	(Liquidity ratio + Equity debt ratio + Sales period expenses ratio)/3	%	CSMAR and WIND
	Environmental conditions	Government subsidies	GS	The ratio of government subsidies to the total assets of the company	%	CSMAR and annual report
		Market pressure	MP	Operating profit ratio	%	CSMAR and WIND

Note: CSMAR, china stock market accounting research; CNRDS, chinese research data services platform.

outcomes are determined by calculating the natural logarithm of the word frequency, incremented by one.

Organisational slack. There are various measures for organizational slack within the academic community. A commonly used approach is based on financial data, which employs the average of the current ratio, the equity-to-debt ratio, and the ratio of selling, general, and administrative expenses to sales (Huang and Li, 2015; Symeou et al., 2019). Specifically, the current ratio, which is the ratio of current assets to current liabilities, reflects a company's investment capacity; an elevated current ratio signifies greater liquidity and financial stability in the short term. The debt-to-equity ratio, which represents the proportion of shareholder equity to debt, reflects the robustness of a company's investments; a higher debt-to-equity ratio suggests a stronger financing capability. The proportion of selling, general, and administrative expenses relative to sales revenue reflects a company's operational efficiency and capacity to manage costs effectively.

3.3.2.3 The third is environmental conditions

Environmental conditions include government subsidies and market pressure. Government subsidies. Following the methodology of Yi et al. (2021), we assess government subsidies by using the ratio of government subsidies (data sourced from each company's annual report) to the company's operating revenue.

Market pressure. In the market, the green preferences of upstream suppliers and customers create market pressure on companies. To maximize profits, firms may engage in green innovation to align with these preferences, thereby increasing profitability. Additionally, highly profitable firms are more likely to attract media attention, and media supervision and reporting further amplify consumer and supplier focus on a company's green behaviors, exerting additional market pressure. Based on the study conducted by Wang et al. (2020), we use the operating profit margin as an indicator of market pressure. The data are standardized to ensure that all values are positive.

The measurements of the antecedent conditions and outcomes and the data sources are summarised in Table 1.

3.4 Measurement of the outcome variable

Many scholars apply the entropy weight method to assess outcome variables. Since Shannon and Weaver (1949) work on information theory, this method has been adopted across engineering and socio-economic studies. The entropy weight method assigns weights to evaluation indicators based on their variability: indicators with lower entropy Ej values, signifying higher variability and more significant information, receive greater weight (An et al., 2024). Here are the steps for evaluating green innovation performance in listed logistics companies using this method:

Step 1: Standardize the original data. The outcome variable comprises four indicators: the ratio of R&D expenditures to business revenue, the number of R&D personnel, ESG evaluation, and the number of green patent applications. Each is a positive indicator, meaning higher values reflect more favorable outcomes. The equation for standardizing these positive indicators is provided in Equation 1.

$$P_{ij} = \frac{X_{ij} - min\left(X_{ij}\right)}{max\left(X_{ij}\right) - min\left(X_{ij}\right)} \quad i = 1, 2, 3 \ldots 83;\ j = 1, 2, 3, 4 \tag{1}$$

In this formula, X_{ij} refers to the original value of the jth indicator for the ith company, while P_{ij} represents the standardized value. The

TABLE 2 The overall values of green innovation performance.

Company name	Value	Ranking	Company name	Value	Ranking	Company name	Value	Ranking
Jiangxi JDL Environmental Protection Co. Ltd.	0.6272	1st	S.F. Holding Co., Ltd.	0.2586	9th	Deppon Logistics Co., Ltd.	0.1722	18th

term max (X_{ij}) represents the maximum value of the *j*th indicator among all companies in the sample; min (X_{ij}) corresponds to the minimum value of the *j*th indicator among all the companies in the dataset.

Step 2: Calculate the entropy value Ej (0≤Ej≤1) and coefficient of variation dj of each indicator. In the entropy weight method, the entropy value Ej and dj of the *j*th index are represented as Equations 2, 3 respectively (Feng and Gong, 2020).

$$E_j = -\frac{1}{ln\,n}\sum_{i=1}^{n} P_{ij} * ln * P_{ij} \tag{2}$$

$$d_j = e - e_j \tag{3}$$

When the entropy weight method is used, *Pij**ln *Pij* = 0 is typically assigned when *Pij* = 0 to simplify the calculation process.

Step 3: Determine the weights of the four indicators. The weight of the *j*th indicator for the *i*th enterprise is calculated and represented as ω_j, as demonstrated in Equation 4.

$$W_j = \frac{d_j}{\sum_{j=1}^{k} d_j} \tag{4}$$

In the equation, *k* denotes the total number of indicators. A larger d_j signifies a greater influence on the indicator, resulting in a higher weight. Once the weights for all the indicators were calculated, the overall values of green innovation performance of the 83 logistics companies were obtained after ranking. Some of the results are shown in Table 2 as examples.

3.5 Data calibration

Data calibration, a crucial part of fsQCA, involves assigning membership scores to the cases analyzed (Hartmann et al., 2022). In line with prior research, the direct calibration method is applied, setting three key calibration points: full membership (above the 90th percentile), the crossover point (50th percentile), and full non-membership (below the 10th percentile). The outcome variable, "green innovation performance," along with six conditional variables—"digitalization level," "technology infrastructure," "CEO's green investment awareness," "organizational slack," and "government subsidies"—are calibrated and labeled as GIP, DL, TI, CGIA, OS, GS, and MP, respectively. The calibration anchor points and results of the descriptive analysis are presented in Table 3.

Following calibration, some cases had a fuzzy-set membership value of exactly 0.5, which can interfere with classification and lead to inaccurate outcomes. To address this issue, 0.001 was added to the membership score of 0.5 after calibration (Fiss, 2011).

4 Results and analysis

4.1 Analysis of necessary conditions

Necessity condition analysis is employed to identify the essential conditions for a particular outcome (Fiss, 2011). According to Ragin (2008), consistency—the uniformity of relationships between conditions and outcomes—is a critical criterion for determining necessary conditions. For a condition to be considered necessary for an outcome (or its absence), its consistency must be greater than 0.9 (Schneider, 2018), and it should demonstrate substantial coverage (the proportion of cases in the sample that share a specific configuration) (Ciampi et al., 2021). The necessity condition analysis conducted via fsQCA revealed that the consistency of the six condition variables was less than 0.9, suggesting that none of the conditions could independently account for either high or low-level green innovation performance in logistics companies. The results are summarised in Table 4.

4.2 Construction of the truth table

In fsQCA, the core method is the "truth table solution," which identifies combinations of factors leading to a particular outcome, clarifying the relationships among cases, conditions, and results (Ragin and Strand, 2008). This study set the consistency threshold at 0.8, the PRI (proportional reduction in inconsistency) threshold at 0.6, and the case frequency threshold at 1 (Pappas and Woodside, 2021). We identified three solution types: complex, parsimonious, and intermediate. These differ in handling counterfactual remainders, representing configurations not observed in the dataset (Ciampi et al., 2021). Complex solutions exclude remainders, covering most configurations, while parsimonious solutions include all remainders without questioning their validity. Intermediate solutions, often used in QCA studies, rely on educated assumptions linking specific conditions to outcomes. Based on these principles, we presented the intermediate solutions in our analysis.

4.3 Configuration analysis of high and low-level green innovation performance

After all possible combinations of the causal conditions are generated and input into the truth table (see Table 5), our study identified two distinct outcomes: high-level green innovation performance and low-level green innovation performance. These outcomes reflect the varying technological, organizational, and environmental factors that lead to the same result—either high or low green innovation performance.

TABLE 3 Fuzzy-set membership calibrations and descriptive statistics.

Variables	Fuzzy-set calibration			Description of sampling			
	Fully in	Crossover	Fully out	Mean (SD)	Minimum	Median	Maximum
Green innovation performance (GIP)	0.256	0.067	0.028	0.113 (0.121)	0.010	0.067	0.627
Digitalization level (DL)	3.854	3.091	1.156	2.858 (1.087)	0.000	3.091	5.656
Technology infrastructure (TI)	0.532	0.131	0.007	0.348 (0.937)	−0.430	0.131	6.793
CEO's green investment awareness (CGIA)	3.972	2.398	1.386	2.533 (1.002)	0.000	2.398	5.043
Organizational slack (OS)	6.66	2.267	0.642	3.095 (2.812)	0.353	2.267	12.813
Government subsidies (GS)	2.039	0.301	0.047	1.121 (3.447)	0.000	0.301	29.399
Market pressure (MP)	0.875	0.795	0.786	2.963 (19.385)	−149.870	1.317	40.363

Note: SD, standard deviation.

TABLE 4 Necessary condition analysis results.

Variable	High-level green innovation performance		Low-quality development	
	Consistency	Coverage	Consistency	Coverage
DL	0.732214	0.620026	0.534739	0.56811
~DL	0.489963	0.456333	0.642345	0.750595
TI	0.580013	0.569827	0.499903	0.616183
~TI	0.609323	0.492675	0.651006	0.660414
CGIA	0.647407	0.574123	0.577847	0.642923
~CGIA	0.597343	0.530033	0.617230	0.687139
OS	0.728031	0.696293	0.470695	0.564807
~OS	0.544970	0.450740	0.746899	0.775057
GS	0.553174	0.549888	0.521337	0.650204
~GS	0.648113	0.519046	0.639098	0.642156
MP	0.658816	0.676853	0.431269	0.555900
~MP	0.567734	0.443097	0.749302	0.733718

Note: Data are generated from fsQCA, 4.1 software. "~" is used to represent the lack of a condition.

Table 5 presents the findings from the fuzzy set analysis for both high and low levels of green innovation performance. The analysis reveals six solutions with satisfactory consistency levels (≥ 0.80) and the presence of eleven core conditions and one peripheral condition. "Solution coverage" refers to the collective proportion of the sample that can be explained by all configurations surpassing the consistency threshold. Among these, two solutions (S1 and S2) signify high-level green innovation performance, whereas four solutions (NS1a, NS1b, NS2a, and NS2b) signify low-level green innovation performance. The overall solution consistency is 0.8563, and the overall solution coverage is 0.3768. This finding indicates that the two configurations explain 85.63% of the variance in high green innovation performance among listed logistics companies, with 37.68% of the cases being accounted for by these two configurations. Additionally, the findings reveal four configurations that result in low green innovation performance. These can be categorized into two types of configurations based on their core conditions: NS1 and NS2. These configurations demonstrate the conditions for low green innovation performance and represent 41.09% of this outcome variable. Essentially, 41.09% of the cases with low green innovation performance are driven by the factors of NS1 and NS2, highlighting the characteristic of causal asymmetry in the fsQCA.

4.3.1 Paths to high-level green innovation performance

S1: Core competencies and market pressure driven. To achieve high green innovation performance in logistics enterprises, three dimensions of factors must be linked and aligned: technology, organization, and the environment. This finding supports the validity of the TOE framework for green innovation in logistics. Configuration S1 (DL*TI*CGIA*OS*MP) represents this model, where the digitalization level, technology infrastructure, CEO's green investment awareness, organizational slack, and market

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TABLE 5 High and low-level green innovation performance.

Type	High-level green innovation performance		Low-level green innovation performance			
Conditions	S1	S2	NS1a	NS1b	NS2a	NS2b
DL	●	●		⊗	⨂	⨂
TI	●	●	⨂	⨂	•	
CGIA	●	●	⨂	⨂	●	●
OS	●		⨂	⨂	⨂	⨂
GS		●	⨂	⨂		⊗
MP	●		⊗		⨂	⨂
Consistency	0.8563	0.8615	0.9276	0.9565	0.9353	0.9525
Raw coverage	0.2768	0.2424	0.2359	0.2424	0.1691	0.2435
Unique coverage	0.0376	0.0216	0.0331	0.0396	0.0246	0.0599
Overall solution coverage	0.3768		0.4109			
Overall solution consistency	0.8563		0.9294			

Data source: Obtained from fsQCA, 4.1 software. Note: Core conditions are marked with ● to denote their presence and with ⨂ to denote their absence; peripheral conditions are shown with • for presence and ⊗ for absence; causal conditions are represented by blank spaces when they are either present or absent. S_1 represents Configuration 1 for achieving superior green innovation outcomes, while NS_1 signifies the first configuration for achieving inferior green innovation outcomes, and so on.

pressure are key factors. In this configuration, advanced digitalization and technology infrastructure enhance resource integration and information sharing. In contrast, the CEO's awareness and available slack resources enable firms to adjust strategies and resource allocation in response to market pressure, boosting green innovation performance. This path illustrates the synergy among technological, organizational, and environmental factors in high-level green innovation in logistics companies. Four firms, including Jiangsu Azure Corporation, S.F. Holding Co., Ltd., etc., serve as case studies, with an average green innovation performance score of 0.2136, significantly higher than the overall average of 0.1133. This finding indicates that, with unstable government subsidies and high market pressure, companies can leverage strong internal technological capabilities, ample resources, and heightened CEO awareness to enhance green innovation performance (Diwei Lv et al., 2020; Karlilar et al., 2023). In summary, this path underscores the critical role of core competencies and market pressure in driving logistics companies to achieve high-level green innovation. This finding resonates with previous research highlighting that digital transformation, the educational background of top executives, and customer green expectations are conducive to a firm's green innovation (Liu et al., 2023; Tang et al., 2021; Abed, 2020; Zhang et al., 2020).

S.F. Holding Co., Ltd. is a notable example of a company that exemplifies the synergy of these factors and achieves high green innovation performance through strong core competencies and market pressure. As one of China's largest Asian logistics companies, ranked 9th among 83 firms, S.F. is a prime example of high-level green innovation for S1. Despite receiving $81.78 million in government subsidies in 2022, only 0.07% of total revenue, S.F. excels in technological and organizational conditions. Its higher keyword frequencies for "digitalization level" (3.7) and "CEO's green investment awareness" (3.2) indicate a strong commitment to improving its digitalization level and technology infrastructure, which is further reflected in their proportion of R&D expenses in business revenue: 3.35% (higher than the average value: 0.75%). Moreover, S.F. employs digitalization to increase efficiency and cost-effectiveness, implementing the "Fengzhi" logistics decision-making model for intelligent analysis and route optimization. Through various green innovation initiatives, S.F. secured eight green patents and achieved an ESG score of 88.8, well above the average of 64.1, ranking on Fortune's list of influential Chinese ESG companies.

S2: Technological innovation and government subsidies driven. In the configuration, S2 (DL*TI*CGIA*GS), digitalization level, technology infrastructure, CEO's green investment awareness, and government subsidies play a core role. This configuration, called "technological innovation and government subsidies driven," explains 24.24% of high green innovation performance cases among listed logistics companies. Unlike configuration S1, the core condition shifts from organizational slack and market pressure to government subsidies. The COVID-19 pandemic may have contributed to this phenomenon by causing a short-term decline in logistics companies' performance, prompting the government to provide financial subsidies to mitigate these effects (Zhao et al., 2023). Three firms, including Transfar Zhilian and Deppon Logistics, have an average green innovation score of 0.2453, higher than the industry average of 0.1133. Green innovation involves significant costs and imitation risks. Firms ' green innovation capabilities weaken without slack resources or external market pressure. Government subsidies help address these issues by alleviating financial pressure, reducing innovation risks, and motivating companies to pursue green innovation for policy support, ultimately boosting green innovation performance. The research findings presented here underscore the pivotal role of digitalization level, technology infrastructure, CEO's green investment awareness, and government subsidies as fundamental prerequisites for augmenting the green innovation performance of logistics enterprises, thereby corroborating prior scholarly investigations (Xu and Li, 2024; Inkinen and Hämäläinen, 2020; Liu et al., 2023).

A prominent example of a company that demonstrates the integration of these factors and achieves superior green innovation performance through substantial technological innovation and government subsidies is Deppon Logistics Co., Ltd. As a leader in China's large package express delivery industry, ranked 18th among 83 firms, Deppon is a key example of high-level green innovation in configuration S2. Deppon faces significant challenges in responding to environmental changes, with an organizational slack resource value of 2.15%, below the industry average of 3.09%. This has resulted in insufficient internal funding capacity for green innovation. Deppon also lacks market pressure, with a value of 2.48%, compared with an average of 2.96%. However, in 2022, Deppon received $3,366,888 in government subsidies, which accounted for 16.50% of its net profit. Deppon used this support for green innovation, introduced environmentally friendly products such as recycling bags and recyclable packaging boxes, and established an innovative logistics system. These measures effectively reduce costs and minimize environmental pollution. With the aid of these government subsidies, Deppon achieved significant results in its green innovation activities and was awarded the honor of being a member unit of the "Sina Weibo ESG Responsibility Action·Sustainable Development Action Plan" in 2023.

4.3.2 Paths to low-level green innovation performance

To enhance our understanding of green innovation in logistics firms, we further analyzed the configurations that lead to low-level green innovation. As shown in Table 5, four configurations result in low green innovation performance, with an overall consistency of 0.9294 and a coverage of 0.4109. These findings indicate that these four configurations account for 92.94% of the explanations for low-level green innovation performance, with 41.09% of the cases explained by them. Based on their core conditions, these configurations can be classified into two categories: Pattern 1 (lacking internal competencies and government subsidies) and Pattern 2 (lacking execution capability and market pressure).

Pattern 1: Lacking internal competencies and government subsidies (NS1). This category includes configurations NS1a and NS1b. A comparison of paths NS1a and NS1b reveals that when technology infrastructure, CEOs' awareness of green investment, organizational slack, and government subsidies coexist but are absent from the core conditions, the digitalization level and market pressure can substitute. Specifically, in configuration NS1a, the digitalization level acts as a missing or insignificant condition. At the same time, the absence of market pressure is a marginal condition that complements this configuration, explaining approximately 23.59% of cases of low green innovation performance among listed logistics firms. In configuration NS1b, market pressure is the missing or insignificant condition, and the absence of the digitalization level functions as a marginal condition, accounting for approximately 24.24% of the low green innovation performance cases. In these configurations, firms exhibit weak internal technological infrastructure and CEO awareness of green investment, limited slack resources, and a lack of external government incentives, leading logistics companies to prefer conservative strategies and avoid high-risk, high-investment green innovation activities (Thomas et al., 2021; Yang et al., 2023).

Pattern 2: Lacking execution capability and market pressure. The second category includes configurations NS2a and NS2b, identifying CEOs' awareness of green investment as a core condition. At the same time, the digitalization level, organizational slack, and market pressure are absent as core conditions. The key distinction is that in NS2a, technological infrastructure serves as a peripheral condition that provides complementary support, with government subsidies either present or absent. This configuration accounts for approximately 16.91% of the low green innovation performance cases. In contrast, in NS2b, the absence of government subsidies plays a complementary role, with technological infrastructure being either present or absent, explaining about 24.35% of low green innovation performance cases.

Comparing paths NS2a and NS2b, we can conclude that when the CEO's awareness of green investment is present as a core condition, the digitalization level, organizational slack, and market pressure coexist but are absent as the core conditions, technological infrastructure, and government subsidies can replace each other. In these configurations, despite a strong CEO awareness of green investment, firms have limited internal slack resources and face low external market pressure for green initiatives, resulting in low digitalization levels and insufficient motivation and resources for high-level green innovation. Therefore, when companies lack internal slack resources and external market pressure, they cannot achieve a high level of digitalization and high-level performance in green innovation.

In conclusion, based on the above analysis, to enhance green innovation performance in the logistics sector, none of the identified factors must be absent as a core condition (Miao and Zhao, 2023; Tang et al., 2021; Zhang et al., 2020).

4.4 Robustness analysis

Robustness analysis is conducted to evaluate the configuration analysis's resilience (stability and reliability) by applying alternative discriminant norms. Drawing inspiration from the works of Fiss. (2011), this study modifies both the case and consistency thresholds. Initially, the case threshold was changed from 1 to 2, which produced consistent results in the newly defined configurations. Next, the consistency threshold was adjusted from 0.8 to 0.85, yielding consistent findings in the revised configurations. The results indicate that the combinations of solutions that enhance high-level green innovation performance in logistics firms align perfectly with previous outcomes, demonstrating a high level of robustness.

5 Discussions

Drawing on the TOE framework, this research developed a theoretical model to explore the trajectory and determinants of green innovation success within logistics companies. The study scrutinized the green innovation efforts of 83 publicly traded firms, assessing both the inputs and outcomes to identify the key configurations that result in enhanced green innovation performance. Through this analysis, the research revealed the mechanisms and contextual factors that shape the impact of technology, organization, and environment on logistics firms' superior green innovation performance. Furthermore, this study expands upon the TOE framework by incorporating technology, organization, and environment elements as key variables. This study provides an in-depth view of how these factors interact and which conditions are essential for promoting green innovation and the prosperity of logistics firms in the Chinese context. This comprehensive approach to understanding the dynamics of green innovation within logistics companies contributes to the existing body of knowledge and offers practical insights for industry stakeholders.

5.1 Theoretical implications

Firstly, this research explores the mechanisms driving green innovation in logistics enterprises, extending the application of the TOE framework. We comprehensively view green innovation drivers by incorporating technological factors, organizational elements, and environmental influences into three dimensions. This approach counters previous studies that focused solely on a singular dimension (Sureeyatanapas et al., 2018; Agyabeng-Mensah et al., 2020), offering a more holistic understanding of their interconnected roles in fostering green innovation. By integrating these three dimensions into the analytical framework, the study extends the understanding of the influencing factors of green innovation performance from external and internal perspectives. Furthermore, a thorough analytical framework is constructed to assess the green innovation performance of logistics companies.

Secondly, our methodology broadens the spectrum of research tools for examining enterprise innovation topics. Little research has examined corporate green innovation from a configuration perspective in recent years. This paper adopts a configuration perspective and employs the fsQCA methodology to construct a research model that examines the concurrent synergistic effect and alignment of various factors within the TOE framework, including technology, organization, and environment. This approach aims to improve the green innovation performance of logistics companies. On the one hand, this study expands the application of the TOE framework to address complex causal issues, thereby enhancing the theoretical depth of TOE theory. On the other hand, the empirical results uncover two pathways that lead to high green innovation performance and four pathways that result in low green innovation performance for logistics companies, which demonstrates that various configurations focused on technology, organization, and environment can achieve high-performance green innovation in logistics firms through "different paths to the same goal." Therefore, from a holistic configurational viewpoint, this study explores different configurations that lead to high- or low-level green innovation, providing insights into the "black box" of high-performance green innovation in logistics companies.

Finally, to further enrich the theoretical framework, this study explores the intricate dynamics between internal and external drivers within the context of Chinese logistics enterprises. The research emphasizes how these factors collectively enhance green innovation capabilities by highlighting the interplay between a company's slack resources, technological readiness, and environmental pressures. Building on insights from Ganda (2019) and Abed (2020), the study shows that while adequate slack resources and government support are essential for reallocating funds toward green initiatives, their effectiveness depends on the strategic alignment of internal capabilities and external pressures. Specifically, the study finds that achieving high green innovation requires a CEO's commitment, optimal utilization of available resources, and responsiveness to market demands. Furthermore, it demonstrates that within the Chinese context, internal strengths such as technological proficiency and organizational agility can be effectively complemented by external factors like regulatory incentives and market competition, thereby creating a favorable environment for sustainable development.

5.2 Practical implications

The research findings offer two key implications for government entities and managers in logistics companies.

Firstly, from the perspective of logistics managers, there are two key approaches to achieving high-level green innovation performance in the sector. Managers must adopt a holistic approach, considering the interplay between internal and external factors rather than focusing on one aspect (Ganda, 2019). Employing a configuration coordination mindset, they can make informed decisions that drive green innovation performance. For example, when government financial support is limited and market pressure is strong, firms can adopt the "core competencies and market pressure driven" strategy (S1). This involves leveraging slack resources to invest in green innovations, such as designing route optimization software, reducing packaging, and installing energy-efficient lighting to enhance operational efficiency and reduce environmental impact. Conversely, when fiscal support is abundant, firms with less solid internal capabilities can opt for the "technological innovation and government subsidies driven" strategy (S2). This approach allows them to strengthen supply chain collaboration, enhance corporate social responsibility, and overcome resource limitations. Additionally, low green innovation performance in configurations NS1b, NS2a, and NS2b is associated with lacking digitalization and organizational slack as core conditions. Therefore, it is essential for companies to effectively leverage slack resources, build digital teams, and embrace AI to accelerate industry-wide digitalization and avoid low-level green innovation performance.

Secondly, from the perspective of departments, they should fully utilize the "visible hand" to promote green innovation in logistics companies. On the one hand, they should effectively use subsidy policies to encourage green innovation behaviors. The research results show that government subsidies play a core role in the configurations leading to high green innovation performance (S1 and S2). In contrast, subsidies are absent in configurations associated with low performance (NS1a and NS1b). This highlights the importance of government subsidies in helping companies bridge internal resource gaps, expand financing channels, and strengthen their commitment to green innovation. Therefore, the government should implement effective financial policies to support companies' green innovation activities. On the other hand, the study indicates that market pressure is a key factor in high-performance configurations (S1 and S2) but absent in low-performance ones (NS1a and NS2). This underscores the role of external pressures in motivating companies to engage in green innovation. Governments can further enhance public awareness of environmental issues and promote green consumption, influencing logistics firms to adopt sustainable practices and strengthen the external push for green innovation.

5.3 Limitations and future directions

This study has the following limitations: First, the sample comprises only 83 listed logistics firms from China's A-share and Hong Kong markets in 2023, excluding those listed in other countries or regions (e.g., Shengfeng Development Limited in the U.S. and EKH LIMITED in Singapore). Subsequent research could expand the scope to include all globally listed Chinese logistics companies, thereby achieving a more exhaustive examination of the strategies for enhancing high-level green innovation performance among these firms. Second, while fsQCA was employed to explore the configurational aspects of high-level green innovation performance across technological, organizational, and environmental dimensions, it is important to recognize that the business environment is inherently complex. Various additional factors, such as company size and regional economic development levels, could influence the green innovation performance of logistics companies. Future studies could benefit from identifying a broader range of cases and integrating a more comprehensive set of antecedent conditions into the analytical framework, drawing from diverse theoretical perspectives to explore the drivers of high green innovation performance in logistics companies. Third, the field of studying high-level green innovation performance in logistics firms is relatively nascent, and the measurement of outcome variables is not yet well-established, potentially introducing biases into existing methods. Future research could focus on developing more refined measurement scales to assess the developmental level of logistics enterprises comprehensively, thereby enhancing the thoroughness and universality of the study.

6 Conclusion

Based on the TOE framework theory, this paper employs fsQCA to investigate the configuration strategies that lead to superior green innovation performance in businesses from the perspectives of internal (technological and organizational) and external (environmental) factors. The research focuses on 83 listed logistics companies in China's mainland and Hong Kong stock markets, yielding several key findings: First, the study identifies no necessary condition that exclusively determines the outcome. While no individual variable can solely influence the green innovation performance of logistics firms, factors such as the level of digitalization, technology infrastructure, the CEO's awareness of green investments, organizational slack, and government subsidies are significantly implicated in achieving high green innovation performance. Second, the research reveals two distinct configurations that lead to high green innovation performance: core competencies and market pressure driven, as well as technological innovation and government subsidies driven. A dual influence shapes green innovation in logistics companies—both the external and internal elements, including technological aspects (digitalization level and technology infrastructure), and organizational aspects (the CEO's green investment awareness and organizational slack), as well as environmental aspects (market pressure and government subsidies). Third, the study revealed that without market pressure, organizational slack, and digitalization level, even a strong CEO commitment to green investments is insufficient for companies to avoid low-level green innovation performance. These findings contribute to academia by establishing new analytical frameworks to assess the determinants of green innovation performance of logistics companies. They elucidate the complex interplay between external (environmental) and internal (technological and organizational) factors and identify the specific factors that can lead to high-level green innovation performance, thereby enriching the existing body of research.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding authors.

Author contributions

SL: Conceptualization, Funding acquisition, Resources, Writing–original draft, Writing–review and editing. JZ: Validation, Writing–original draft, Writing–review and editing. PC: Validation, Writing–original draft, Writing–review and editing. ZL: Investigation, Methodology, Supervision, Writing–original draft, Writing–review and editing. CL: Formal Analysis, Methodology, Software, Supervision, Writing–original draft, Writing–review and editing. WF: Supervision, Validation, Resources, Software, Writing–review and editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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